

Engineered for excellence

Design, qualification, manufacturing and assembly

A fully customized high-voltage cable connector



2Connect



An OEM customer in the semiconductor industry required a high-voltage cable connector for a vacuum chamber. 2Connect elaborated the customer's concept into a design that served as a proof-of-principle. For prototyping, metal, ceramics and high-performance polymer parts were produced. After assembly and testing of the prototype, leading to a successful qualification, 2Connect finalized the design into a mature product that fully met the requirements while manufacturability was optimized. Now, parts for the series product are sourced from specialist suppliers and final assembly and testing of the cable connectors are performed in-house.

Outlining the scope

The customer required a high-voltage (HV) cable connector operating at 30 kV, with a 10 kV pin-to-pin potential difference, in a 2-pin and a 5-pin configuration, mating onto a pre-defined feedthrough connector on a vacuum chamber. After successful qualification of the connector design, the supply forecast amounted to a dozen or more products on a yearly basis.

The customer commissioned 2Connect to:

- elaborate the design, starting from the customer's concept;
- produce a proof-of-principle and qualify the concept design;
- finalize the design and optimize manufacturability;
- prepare for series production.

Defining the requirements

The complex connector required customized designs for most parts, as no off-the-shelf solutions were available. The challenges included the HV application, the sealing requirements, and the constraints imposed by the design of the counter socket, i.e. the pre-defined feedthrough connector on the customer's vacuum chamber. Given this challenging nature, the project started with an extensive analysis of the concept in close consultation with the customer. This included model simulations of various functional and material aspects of the connector.

The global customer requirements combined with the analysis and simulation results were translated into detailed requirements for the connector design:

- Tight form factor.
- Minimal air gaps within the connector.
- Sufficient HV insulation in the mated state.
- Water tightness in the mated state.
- Safety compliance.
- Easy assembly of the cable-connector.

Prototyping

Starting from the requirements, solutions for the various technical challenges were elaborated (see the Technical solutions box) and a proof-of-principle design was completed. A prototype was produced by 2Connect, drawing on its wide range of manufacturing capabilities. These include machining of metal (stainless steel and brass), ceramics and high-performance polymer (PEEK) parts, as well as laser welding for assembly of the connector.

Functional testing was conducted in-house to a large extent; final testing required the availability of the complete system including the counter socket and the HV facilities at the customer site. In close collaboration with the customer the prototype was successfully qualified.



Technical solutions

✓ Air gaps

The high electrical field of the HV connection can ionize the air present within the connector, potentially causing flashovers and connector degradation. In order to prevent this, air gaps have to be minimal in the mated state. The design complied with a detailed list of maximum allowable air gaps, in the micrometer and millimeter region, based on electrical simulation. One of the prime solutions was to move part of the insulation from the connector onto the feedthrough, on which a Teflon tube was pressed. This solution achieved zero gap and minimal friction between connecting parts, and relieved the 'zero-tolerance fit' constraint.

✓ HV insulation

With the 10-kV pin-to-pin potential difference, prevention of flashover was critical. This required that the pin-to-pin distance was sufficiently large, both directly through air (clearance distance) and via the surface of the plastic insulation (creepage distance). The creepage distance was increased by extending the insulation cover of each pin, while the clearance distance problem was solved by repositioning insulation parts to create a labyrinth-like structure in which pins did not 'interact' with each other.

✓ Water tightness

In the mated state, water tightness of the connection prevents short-circuiting when cleaning with water. To this end, the O-ring in the concept was replaced by a star-shaped seal that covered the complete interface to provide a waterproof protection. The design of this rubber seal required specialist knowledge. It had to be self-adhesive and was provided with the right amount of pre-tensioning to facilitate mounting of the connector and to maximize the sealing effect.

✓ Safety and grounding

Naturally, the design complied with the safety regulations. In particular, attention was paid to the grounding cable braid. The design provided a sound contact of the braid with the metal outer case of the connector. After assembly, the internal space was completely potted to fix the components and to minimize the amount of air inside the connector. To ensure a reliable electrical contact of the connector with the HV cable and its grounding braid, strain-relief parts were integrated in the design of the connector.





Finalizing the design

From in-depth analysis of the design and the test results, it was concluded that, in principle, the design was first time right. Only minor modifications were required for the final design, mainly concerning materials selection: finding the optimum rubber formulation for the seal, and replacing brass parts with stainless-steel parts.

To conclude, the design-for-manufacturing and design-for-assembly were refined and the modular product structure, already defined in the concept phase, was optimized. As a result, the various parts can each be manufactured efficiently, while assembly is facilitated, for example through a shape-optimized fit between parts and by using pretension.

Organizing production and assembly

For series production and assembly, the design drawings were finetuned with respect to dimensions and tolerances. Specialist suppliers were selected for the various critical parts. Assembly and quality control were organized in-house, with dedicated tooling required because of the high degree of product customization. Testing procedures for the series production were defined in consultation with the customer. As a result,

2Connect can perform series production and assembly effectively and efficiently.

Building on collaboration

Following the successful completion of the connector design project, the customer decided to commission 2Connect to supply the series product. This marked the end of a “high-voltage” project in which 2Connect development abilities were tested. Taking a broad perspective and putting in creative outside-of-the-box thinking as well as comprehensive connector expertise and extensive materials knowledge, 2Connect managed to live up to this challenge.

The availability of professional manufacturing facilities accelerated the development process, by providing instant feedback and enabling intensive communication between all disciplines involved: design engineers, machine operators and assembly engineers internally, as well as the customer and external suppliers. In this way, a short lead time for the proof-of-principle was achieved, which was essential for the customer in this complex development project that depended on the feasibility of various critical component designs. In the end, this accomplishment clearly demonstrated 2Connect’s all-round development capabilities.

2Connect

2Connect B.V.

Van Harenstraat 2
NL-5145 RJ Waalwijk
The Netherlands

Tel +31 (0)416 671780
Email info@2-connect.com
2-connect.com